and *Otina*, belonging to the *Auriculea*, with those of *Succinea* and its allies. From the shell alone, which has the form of *Otina*, with the substance, texture, and peculiar external ridge and internal furrow of *Camptonyx*, I should have supposed the present species to belong to the last-named genus; but the retractile eye-bearing peduncles prove its place to be in the neighbourhood of *Succinea*, from which genus the internal furrow for a siphon distinguishes it as a well-marked subgenus. Tentacles are extremely small and rudimentary in several of the subgenera of *Succinea*, and, in the present case, appear to be wanting; if present, they are certainly very inconspicuous. The animal of *Helisiga*, Less., as represented in Adams's Gen. Rec. Moll., pl. 73, closely resembles that of *Lithotis*, but has a larger foot, while the shell only differs in the absence of the siphonal furrow.

Lithotis abounds adhering to the precipitous basaltic rocks of the Western Ghats, like *Cremnobates*, but apparently in rather more exposed situations, being perhaps more purely an air-breather, and requiring less moisture than its congener. Both probably feed upon the confervoid vegetation covering the surface of the rock to which they adhere.

I am indebted to the kindness of Mr. A. B. Mynne for the accompanying drawings of the shells above described.

EXPLANATION OF PLATE IV.

Figs. 1, 2. *Cremnobates Syhadrensis*, natural size.
Fig. 3. The same, enlarged 2 diameters.
Figs. 4, 5. The same; operculum enlarged 2 diameters.
Figs. 6, 7. Animal of the same.
Figs. 8, 9, 10. *Lithotis rupicola*, natural size.
Fig. 11. The same, enlarged 2 diameters.
Fig. 12. The same; animal from below.

XIX.—*On Cephalization, and on Megasthenes and Microsthenes in Classification (being in continuation of an Article on the Higher Subdivisions in the Classification of Mammals).* By James D. Dana*.

In the paper on the "Classification of Mammals," published by the writer in Silliman's Journal (vol. xxxv. p. 65)†, and also in his earlier paper on Crustaceans, the principle of cephalization is shown to be exhibited among animals in the following ways:—

1. By a transfer of members from the *locomotive* to the *cephalic* series.

* Communicated by the Author. From the 'American Journal of Science and Arts,' vol. xxxvi. (July 1863).

† See Ann. and Mag. Nat. Hist. March 1863, p. 207.

2. By the anterior of the locomotive organs participating to some extent in cephalic functions.

3. By increased abbreviation, concentration, compactness, and perfection of structure, in the parts and organs of the anterior portion of the body.

4. By increased abbreviation, condensation, and perfection of structure, in the posterior, or gastric and caudal, portion of the body: as, in the greater compactness and larger number of segments combined in the sacrum of the *higher Megasthenes* than in that of *Cetaceans* or *Edentates*; the less posterior elongation of the vertebral column and body in the *higher Megasthenes* than in *Cetaceans,* or in the *tailless Batrachians* than in the *tailed* species of the group, &c.

5. By an upward rise in the cephalic end of the nervous system. This rise reaches its extreme limit in Man. Birds thus show their superiority to Reptiles, but not to Mammals; for the Bird-type, like the Reptilian, is relatively diminutive in life-system (*infrà,* p. 196); its relation to the Reptilian type is much like that of Insects to the Crustacean (p. 193).

A decline in the grade of cephalization is shown by the reverse of these conditions: as (1) by a transfer of members from the cephalic to the locomotive series; (2) by the posterior cephalic organs participating in locomotive functions; (3, 4) by increased laxness, length and breadth, or spacing, among the parts of either the anterior or posterior portion of the body, or, further, a resolution, more or less complete, of the system of structure into its equal normal elements or elementary parts; (5) by increased proneness in the position of the nervous system: also—

6. By an adaptation of the organs of the senses to locomotive or prehensile purposes,—as in the case of the proboscis of the Elephant, which is a perverted nose; also the prehensile terminations of the second antennæ of many inferior Crustaceans.

7. By an abnormal multiplication of the parts in the anterior portion of the body,—as in the excessive number of teeth in some *Cetaceans* and *Edentates.*

8. By an abnormal multiplication of the parts in the posterior portion of the body,—as in the abnormal multiplication of members and segments in *Phyllopod Crustaceans, Myriapods,* &c.

9. By a further degradation of the structure before and behind, or a degeneration or obsolescence of the parts or organs,—as in the absence of teeth in some *Cetaceans* and *Edentates*; the degradation of feet into fins, as in *Whales,* or their total absence; the absence of a series of abdominal members in *Entomostracans*; the absence of antennæ in Articulates, *provided* the senses corresponding to these organs are absent or comparatively imperfect;

the coalescence of the head and thorax, or of these with the abdomen; the extension of the gastric viscera towards, or into, the head.

10. By excessive size of body through mere vegetative enlargement,—as in the *Megatherium*, the *female Bopyrus, Limulus*, &c.

Degradation, or a decline *below the normal* level, may hence be—

I. *Multiplicative.* Methods 7, 8, above.

II. *Degenerative.* Methods 3, 4, 9.

III. *Vegetative.* Method 10. Also IV. *Phytoid* (or *plant-like*), when animals (as *Polyps*) have (11) the power of budding, or (12) a radiate structure, or (13) attachment below; and in such cases the decephalization is often almost as complete as in plants*.

Examples of *cephalization* by the first method, or by a transfer of members from the locomotive to the cephalic series (or of *decephalization* by the reverse), occur in the two highest subkingdoms, those of *Vertebrates* and *Articulates*. They fail in the two lower subkingdoms, those of *Mollusks* and *Radiates*, because of the absence of the necessary structure for showing it.

The examples under *Vertebrates* and *Articulates*, and the relations of the orders among *Mollusks*, may be briefly considered.

I. *Vertebrates.*—Only a single example in the class of Mammals, or even in the whole subkingdom of Vertebrates, is possible, owing to the fixed nature and simplicity of the head, and also the limited number of feet, two pairs being the maximum.

This one example has already been pointed out and shown to be the basis of the grand distinction between Man and other Mammals. In passing downward from the exalted position which Man holds, there is a transfer of the fore limbs to the locomotive series: the structure of the head in Vertebrates, even

* The methods of decephalization in Crustaceans are embraced under *two* heads, by the writer, in his paper on the Classification of Crustaceans (Silliman's Journ. ser. 2. vol. xxii. p. 28, and Expl. Exp. Rep. on Crustacea, p. 1412), as follows:—

"1. A diminution of centralization, leading to an enlargement of the circumference or sphere of growth at the expense of concentration, as in the elongation of the antennæ and a transfer of the maxillipeds to the foot-series, the elongation of the abdomen and abdominal appendages, &c.

"2. A diminution of force as compared with the size of the structure, leading to an abbreviation or obsolescence of some circumferential organs, as the posterior thoracic legs or anterior antennæ, or the abdominal appendages (where such appendages exist in the secondary type embracing the species).

"These circumstances, moreover, are independent of a degradation of intelligence by an extension of the sphere of growth beyond the proper limits of the sphere of activity."

to the lowest Fishes, admits of no other case of analogous transfer*. In the *Walrus* the tusks have some locomotive functions, as they serve to rest the fore part of the animal, or its head, on the ice while the body is in the water; but this is an example under the *second* method. The feet are wholly absent in *Snakes*, and the ribs aid in locomotion; but this is only a degradation of the Vertebrate type, and not decephalization by the first method. In most *Fishes*, and in *Whales*, the locomotive function is transferred mainly to the elongated vertebrated posterior extremity of the body—a case of *degenerative* degradation similar to the last, and analogous also to the *multiplicative*.

It is of sufficient interest in this connexion to be repeated here, that among Mammals the four orders of Megasthenes exhibit in their *fore limbs* four distinct grades of cephalization: in the *Quadrumanes* these organs serve for carrying their young, supplying the mouth with food, taking their prey, and for locomotion; in the *Carnivores*, for taking their prey and for locomotion; in the *Herbivores*, for locomotion only; in *Mutilates*, for fish-like locomotion, the members having the degraded form of fins.

II. *Articulates.*—In the subkingdom of Articulates, the three classes are *Insecteans*, *Crustaceans*, and *Worms*: the first includes Air-breathing species (*Insects*, *Spiders*, and *Myriapods*), and the second and third the Water-articulates. Examples of cephalization by the *first* method occur in the first two of these classes. They cannot in the third, because Worms have no proper feet, and are not a type with *closed* limits, but one admitting of indefinite multiplication of parts behind, and therefore *open* posteriorly.

1. *Insects*, the highest of the three orders of Insecteans, have three pairs of mouth-organs and three pairs of legs. As the wings belong to the same segments of the body with two of the pairs of feet, they are not to be counted; for the transfer noted is, in fact, a transfer of *segments* of the body along with their appendages.

Passing down from Insects to *Spiders*, the mouth loses one

* To the *zoological* characteristics of Man, mentioned in the writer's article on Mammals (that is, the extreme cephalization of his system, and the erect form connected therewith) should be added the following,—that, while in the Quadrumanes the feet are clasping or prehensile feet, in Man they are simply organs of support and locomotion. The former fit the Apes for their climbing habits, the latter empower Man for human duty. The discussion, now in progress, whether the hind limbs of the Gorilla terminate in hands or in true feet ("in no sense hands," in the words of Prof. Huxley) is of small importance in this connexion.

The writer's view of the characteristics of Man depending on his *spiritual* nature are given in Silliman's Journal, vol. xxxv. p. 452.

pair of organs (the posterior), and the feet gain one pair, there being *four* pairs of feet in Spiders; that is, there is a transfer of *one* pair from the cephalic to the locomotive series. The absence of antennæ in Spiders is no mark of degradation, since the *senses* exist in good perfection.

Descending lower, to the *Myriapods,* the Articulate type passes below the range of normal variation into a degradational form, and one which, like that of *Worms,* admits of indefinite posterior elongation or multiplication of segments (by the *eighth* method of decephalization), and hence it has no *closed* or fixed limits, like that of Spiders or Insects. Under this loose and multiplicative condition of the system, there is no regular transfer backward of another pair of mouth-organs: the type is distinguished, instead, by the degradational character just mentioned.

2. The facts among *Crustaceans* have already been pointed out—that, descending from *Decapods* (Crabs and Lobsters), which have *six* pairs of mouth-organs and *five* of feet, to *Tetradecapods,* two pairs of the mouth-organs are transferred to the locomotive series, making the number of pairs of feet *seven,* and of mouth-organs four.

Descending further, to *Entomostracans,* or the third order, the mouth-organs lose one or more of the remaining pairs, and sometimes (as in *Limulus,* or the Horse-shoe Crab, as it is called) *all,* for the mouth-organs in this species are all true feet. The Entomostracans exemplify decephalization by degeneration (*ninth* method)—as in the absence of one or two pairs of antennæ, the absence of one or two or more posterior pairs of thoracic feet, the absence of the series of abdominal members, and sometimes (as in *Limulus*) by the reduction of the abdomen to a mere spine. They are *degradational* forms as well as the Myriapods; and hence the apparent difference of grade, which might be supposed to be marked by the number of pairs of mouth-organs transferred backward, cannot serve to subdivide the order. The distinction of the Entomostracans from the higher Crustaceans consists rather in their degradational characters than in any peculiarities of the mouth. In the tribe of Ostracoids (*Cypris,* &c.) alone, one genus has *two* pairs of mouth-organs, the rest being legs, another *three,* and another *four,* the Tetradecapod number.

III. *Mollusks.*—It has been remarked that the subkingdom of Mollusks cannot, from its nature, exemplify the *first* method of cephalization. The methods exemplified are the *third, fourth, ninth,* and *tenth.* In the transition from the order of *Cephalopods,* the *first,* to that of *Cephalates* (*Gasteropods*), the *second,* there is a loss of the feet or arms, and a diminished perfection of the senses, and activity is reduced to sluggishness. Descend-

ing to the *third* order, or *Acephals*, the antennæ fail, the eyes become imperfect or obsolete, locomotion becomes very imperfect, and in some fails altogether. Among *Bryozoans*, a still inferior order, all the organs of the senses fail, and there is the radiate structure of vegetation as well as its sessile character.

The difference in cephalization between an oyster and a clam is very strongly marked,—the oyster, when placed in its normal position, having its body nearly all posterior to the beak, being merely a large gastric mass; and the clam having one-third of the body anterior to the beak, and really exhibiting something stately in mien compared with the oyster.

Other illustrations of the subject might be given; but they are not necessary to explain the general principle in view.

The *number of pairs of feet* in the subkingdoms of Vertebrates and Articulates, under those types which afford examples of the first method of cephalization, is as follows:—

I. Vertebrates.

1 in Man; 2 in all other Vertebrates.

II. Articulates.

1. *Under Insecteans.* 3 in Insects; 4 in Spiders.
2. *Under Crustaceans.* 5 in Decapods; 7 in Tetradecapods.

The number of pairs of feet in the different groups are then 1, 2, 3, 4, 5, 7. Only *one* case of typical transfer occurs in each of the three classes illustrating the subject—Mammals, Insecteans, and Crustaceans; and these cases occur uniformly between the *two highest orders* of the class.

Man's title to the place assigned him in our former paper appears therefore to be unquestionable.

The types of Vertebrates and Articulates do not admit of any homological comparisons.

The types of Insecteans and Crustaceans are modifications of a common type; yet the two are so widely different, that it is far from true that the *five* pairs in the highest Crustaceans correspond to the *four* in Spiders *plus* a preceding pair of mouth-organs. The head and locomotive part of the thorax in the Land-Articulates appear to correspond unitedly, as stated by Latreille, to the cephalic portion of the Crab,—that is, to *nine* anterior segments out of the *fourteen* cephalothoracic. In other words, this part of the body of an Insect is an extreme concentration of the anterior portion of a Crustacean—an example of extreme cephalization; while a Crustacean is a diluted

Insect, being much larger, and more numerous in segments and members*.

The *Lobster* (or any ordinary Macrural Decapod Crustacean) has an elongate body, and an abdomen well developed and furnished below with a full series of members. In the male *Crab*, also a Decapod, the body is very short, and the abdomen is without its members, besides being so small that it folds into a groove in the under shell of the body: this diminution of size and increased compactness are a consequence of the higher cephalization of the species (Method 4). Passing from Crabs to the still higher Articulates, *Insects*, there is an example of this cephalization carried to its maximum,—it appearing in the extreme diminution of size of body and members, in the very small distinct head (comprising, normally, *a third* of the segments of the body, though so small), and in the thorax freed from the viscera and devoted mainly to locomotion. By this method an animal is made of the highest instincts under the Articulate type.

From these examples it is evident that, where there is a compacting of the body connected with rise in grade, it is not merely a *general* compacting of the different parts alike, or a general concentration and perfecting of the system, but a true *cephalization* of the system,—the compacting and perfecting showing itself primarily in a greater concentration, predominance, and domination of the cephalic extremity.

Among Articulates having feet, an *Insect* and a *Limulus* stand at the opposite poles of cephalization. The mouth-organs and feet in both correspond to those of the head (or the mouth-

* There appears to be no reason to doubt that in all types, *not degradational*, each pair of members (wings excluded) corresponds to a separate normal segment of the body. Audouin and Edwards are sustained in their views on this point by the fact that, in a *Squilla*, three anterior cephalic segments (those of the eyes and two pairs of antennæ) and four posterior thoracic are actually distinct; and in an *Erichthus*, other segments, anterior to these four, are faintly indicated. (See the author's Expl. Exped. Report on Crustacea, pl. 41.)

Assuming the number of normal segments anterior to the mouth in an Articulate from that (three) in the head of a Crustacean, the complete number in an Insect is *eighteen*, and in a Crustacean *twenty-one, three abdominal* being present which are obsolete in an Insect. In the former, *half* (or *nine*) pertain to the head and thorax (only three to the thorax); in the latter, *two-thirds* (or *fourteen*), the rest being abdominal. In an Insect, the viscera are *abdominal*; in a Crustacean (excepting some degradational forms), *thoracic*. The separation of the viscera from the thorax in an Insect leaves this part to higher purposes. It is to be noted that the tenth to the fourteenth segments, inclusive, are *visceral segments in both Insects and Crabs*,—being the first part of the abdomen in an Insect, and the last (and large-foot-bearing) part of the cephalothorax in Crabs.

organs) of a Crab. But in *Limulus* there is extreme of degradation, all the members being large and stout feet, only the basal joints of the feet serving as jaws,—the body being enormously enlarged by mere vegetative growth,—the antennæ wanting, or reduced to a pair of pincers, and the animal sluggish, a sport of the waves on the beach; while in Insects there is extreme of cephalization, the pairs of feet only *three* and those small and slender, and the body minute in comparison—the antennæ well developed, and serving as delicate organs of sense—the animal active, and wonderful in its instinctive habits and knowledge.

The parallelism above shown between Insecteans and Crustaceans proves that *Insects, Spiders,* and *Myriapods* are orders in a single class, and not separate classes*. Moreover the orders under the classes of Insecteans and Crustaceans constitute parallel series, the first two of each being *closed* types, within the range of normal variation, and the last one of each (*Myriapods* and *Entomostracans*) being a degradational type, though different one from the other in kind of degradation. The parallelism between the series would be well exhibited if the orders were thus named:—

Those of Insecteans, (1) *Hexapods,* (2) *Octapods,* (3) *Myriapods.*

Those of Crustaceans (1) *Decapods,* (2) *Tetradecapods,* (3) *Colopods,* this last term (from κόλος and πούς) signifying *defective feet* or *members,* which is the prominent characteristic of the order.

The parallelism extends even further than has been mentioned. The Tetradecapods are not an intermediate type between Decapods and Entomostracans; on the contrary, they lie quite out of the range of either. The Decapods, in their degradational species, pass almost into Entomostracan forms, and not into Tetradecapod forms. So among Insecteans, the Spiders have the same isolated position and defined limits. Insects, in

* The grand distinction of the subdivision of *Insects* consists in their having three pairs of mouth-organs and three pairs of feet; of *Spiders,* in having two pairs of mouth-organs and four pairs of feet; of *Myriapods,* in having, through degradation, an indefinite number of segments and feet. Hence, to include *Spiders, Myriapods,* and the Hexapod group of *Pulices, Lepismæ, Pediculi,* and the like, in one division called *Aptera,* as is done by some naturalists who adopt the general division of Insecteans, is a violation of all true affinities.

Professor Agassiz recognizes the same three classes of Articulates as above by the writer, and the same subdivisions, or orders, of Insecteans, but "from embryological data." The writer has not felt ready to deprive Spiders and Myriapods of their place in separate classes, co-ordinate with those of Insects, Crustaceans, and Worms (a common method among zoologists), until recently, when the special application to these Articulates of the principle above explained occurred to him.

their degradation, approximate to Myriapods, not to Spiders. In fact, Spiders stand more nearly between Insects and Crustaceans than between Insects and Myriapods.

There is here a cross affinity between Insecteans and Crustaceans which is of great interest. The relation of common *Spiders* to *Brachyural Decapods* or *Crabs* is seen (1) in the general form or habit of body (some Crabs are called sea-spiders), and (2) in the coalescence of the thoracic and abdominal nervous ganglions into a single central thoracic ganglion. At the same time, the division of *Scorpions,* among Spiders, is correspondingly related to that of the *Macrural Decapods,* (1) in the body consisting of a series of segments; and (2) in the nervous ganglions being distinct, one to each abdominal segment. Moreover the maxillipeds are long and chelate, like the outer pair in some inferior Macrurans.

Again, the *Myriapods* are distantly related to the *Tetradecapods,* they being similar in their annulated structure, each segment having its pair of feet, and some species of the former (as those of *Glomeris*) even resembling the latter quite closely in form, articulation, and antennæ, and many of them having also the habit of some *Oniscidæ* (Tetradecapods) of rolling into a ball.

Thus, the *second* order of Insecteans is related, as regards form, to the *first* of Crustaceans; and the *third* of Insecteans to the *second* of Crustaceans.

The earliest of Crustaceans, the *Trilobites,* one of the *comprehensive* types as styled by the writer, are therefore not only intermediate between Entomostracans and Tetradecapods, but also, in some respects, between these and the Myriapods. Moreover, like the latter, Trilobites are abnormal in the very large number of segments of which the body is composed; and sometimes also they present no distinction between the cephalothorax and abdomen.

The facts pointed out prove conclusively that Insecteans and Crustaceans constitute classes of equivalent value.

2. *Megasthenes and Microsthenes.*

The two grand divisions of typical brute Mammals, the *Megasthenes* and *Microsthenes,* are not separated by any very marked difference in type of structure; and still there is a profound fundamental difference between them—that to which the names refer. This is in contrast with the fact among Crustaceans, the Megasthenic and Microsthenic divisions of which (the *Decapods* and *Tetradecapods*) stand widely apart. But in the class of *Crustaceans* the structure varies between remote extremes, while in that of Mammals there is a remarkable fixedness or an extremely limited range of variation. Hence, in the distinctions

of *Megasthenes* and *Microsthenes,* among Mammals, we cannot look for the marked diversity that subsists between *Decapods* and *Tetradecapods,* although the naturalness of the subdivisions is none the less real. The words *Megencephals* and *Micrencephals* (signifying *large-brained* and *small-brained* Mammals) may better satisfy the desire for names expressing something tangible in the structure. Yet they do not appear to indicate the fundamental distinction between the groups. A general structural characteristic may yet be detected corresponding to these megasthenic and microsthenic qualities; but even then the distinctive idea of the subdivisions could hardly be better expressed than by the names proposed.

The parallelism between the Megasthenes and Microsthenes among Mammals, and the Decapods and Tetradecapods among Crustaceans, suggests that if the subdivisions be called *orders* in the latter case, they should be so called in the former.

The distinction between Megasthenes and Microsthenes may perhaps become more intelligible if we regard a living structure as a *life-system,* or, speaking dynamically, a *life-battery.* In order that such batteries may have a very wide range of size, two or more plans of construction, more or less different, appear to be requisite. With one plan, there is a certain magnitude which is that of most efficient action and power; and from this magnitude there may be a series of larger and smaller sizes, reaching to the outer limits of normal perfection, and then, if these limits be passed in either direction (that is, either on the side of too great magnitude or of too little), degradation in the structure and its powers begin to appear.

To carry the species through another range of sizes, with normal perfection of structure, another somewhat different plan is required. The Megasthenes represent one such plan, the Microsthenes another.

This idea is brought out by the writer in his chapter on the Classification of Crustaceans already referred to. He there says, speaking of the orders of Crustaceans, viz. Decapods, Tetradecapods, and Entomostracans:—

"I. Each type corresponds to a certain system of force more or less centralized in the organism, and is an expression of that force,—the higher degree being such as is fitted for the higher structures developed, the lower such as is fitted for structures of inferior grade and size. In other words, the life-system is of different orders for the different types, and the structures formed exhibit the extent of their spheres of action, being such as are adapted to use the force most effectively, in accordance with the end of the species.

"II. In a given type, as the first, for example, the same system may be of different dimensions, adapted to structures of different

sizes. But the size in either direction for structures of efficient action is limited. To pass these limits, a life-system of another order is required. The Macroura, as they diminish in size, finally pass this limit, and the organisms (Mysidæ, for example) are no longer perfect in their members; an obsolescence of some parts begins to take place, and species of this small size are actually complete only when provided with the structure of a Tetradecapod.

"The extreme size of structure admitting of the highest efficient activity is generally three to six times lineally the average or mean typical size. Of these gigantic species, three or four times longer than the mean type, there are examples among the Brachyura and Macroura, which have all the highest attributes of the species. There are also Amphipoda and Isopoda 3 inches in length, with full vigorous powers. Among Entomostraca, the Calanidæ, apparently the highest group, include species that are 3 lines long, or three times the length of the mean type.

"III. But the limit of efficient activity may be passed; and when so, it is attended with a loss of active powers. The structure, as in the female Bopyrus and Lernæoids, and the Cirripeds, outgrows vegetatively the proper sphere of action of the system of force within. This result is especially found in sedentary species, as we have exemplified in our remarks on the Cirripeds.

"IV. Size is, therefore, an important element in the system of animal structures. As size diminishes, in all departments of animal life, the structure changes. To the human structure there is a limit; to the quadrupeds also, beyond which the structure is an impossibility; and the same seems to be the case among Crustacea. The Decapod, as the size diminishes, reaches the lowest limit; and then, to continue the range of size in species, another structure, the Tetradecapodan, is instituted; and as this last has also its limit, the Entomostracan is introduced to continue the gradation; and, as these end, the Rotatoria begin. Thus Crustacea are made to embrace species from a length of nearly two feet (or 250 lines) to that of a one-hundred-and-fiftieth of a line. These several types of structure among Crustacea do not graduate, as regards size, directly from one to another, but they constitute overlapping lines, as has been sufficiently shown."

While on this subject of life-batteries, the writer would suggest that the grand dynamical distinction between Mollusks and Articulates may be this:—

A Mollusk corresponds to a *quantity-battery*, but one of very weak force; that is, it is analogous to a galvanic battery of *two or three small pairs at the most*. This is indicated, (1) by the structure of the species, especially the absence of all articulations, the animal (a locomotive digestive system) being, as it were, in one simple bag; (2) by the number of ganglions, limited to three; and (3) by the sluggishness of the animal.

An Articulate, on the contrary, corresponds to an *intensity-*

battery, or is analogous to a galvanic battery of *many small pairs*; for (1) the body consists of many segments; (2) there are nearly as many nervous ganglions as segments (normally as many); and (3) the animals in the more typical species have extreme rapidity of movement and high instincts. The small number of ganglions in most Spiders is evidently due to a coalescence of several in the one central thoracic ganglion, as in Crabs.

In the highest Mollusks, the Cephalopods (Cuttle-fish, &c.), the Invertebrate *quantity-battery* reaches its greatest power.

Vertebrates also appear to correspond to a quantity-battery (as shown by the simplicity of the nervous system), but to one admitting of vastly greater power.

XX.—*On the Value of the "Villi" on the surface of* Amœba *as a Specific Distinction.* By H. J. Carter, F.R.S. &c.

In Article XIII. of the 'Annals' for August 1863, vol. xii. p. 111, Dr. Wallich calls upon me to account for many things—more than I have time now to answer.

I rejoice, however, to see that he has taken up the study of the freshwater Rhizopoda so zealously, and hope that he may make much progress in it; for, regarding a correct knowledge of these elementary forms of life as, at present, the alphabet, so to write, of organized creation, I shall not be found wanting in gratitude to him for every moment that he may devote, and for the smallest trifle that he may add, to our information respecting the *Amœbæ*; while, if I fail in this, or am guilty of the opposite, viz. of detracting from him, which has not been, nor ever will be, done intentionally, I am certain, on the other hand, that he will obtain that justice and be allowed that priority from those acquainted with the subject, which truth and right in the end always secure in matters patent to public scrutiny. But not being particularly ambitious of such awards myself (as I am for the most part satisfied if I can obtain the publication of anything which I think may be useful, in a truthful form and to the best of my ability), I may perhaps on this account be backward in acknowledging the assistance that I derive from others, where this does not appear to me to be absolutely necessary for the subject on which I may be writing.

I would, however, wish it to be understood that my remarks on *Amœba princeps* ('Annals' for July 1863, p. 30) were chiefly derived from observations made on this species of *Amœba*, in Devonshire, in April last; while those by Dr. Wallich were made in London about the same time on an *Amœba* which he then considered to be such "a well-marked species" that he adds